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Magnitude of Negative Interpretation Bias Depends on Severity of Depression

Jong-Sun Lee[13*], Andrew Mathews[2], Sukhi Shergill[1], Jenny Yiend[1**]

[1]Institute of Psychiatry, Psychology and Neuroscience, King's College London, United Kingdom

[2]Department of Psychology, University of California, Davis, U.S.A.

[3] Department of Psychology, Kangwon National Unversity, Chuncheon, Republic of Korea

*Jong-Sun Lee

Department of Psychology, Kangwon National Univesity, Chuncheon, Republic of Korea

E-mail: jongsunlee@kangwon.ac.kr

**Jenny Yiend

Institute of Psychiatry, Psychology and Neuroscience, King's College London

PO 63, De Crespigny Park, London SE5 8AF, UK

E-mail: jenny.yiend@kcl.ac.uk

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Abstract

The present study investigated the hypothesis that the magnitude of negative interpretation bias displayed by those with depression is related to the degree of depression they experience. Seventy one depressed participants (scoring 14 and above on the Beck Depression Inventory II) completed tasks spanning three domains of possible negative interpretations: semantic ambiguity; nonverbal ambiguity and situational ambiguity. Regression analyses revealed that just under half of the variance in depressive symptom severity was explained by the combination of negative interpretation bias tasks, with the strongest predictor of depressive symptom severity being negative interpretation of semantic ambiguity when reading ambiguous text descriptions. Subsidiary group analyses confirmed that severely depressed individuals interpreted emotionally ambiguous information in a more negative way than did their mildly or moderately depressed counterparts. These findings indicate that the degree of negative interpretive bias is closely related to depression severity and that bias manifests especially strongly at the most severe levels of depression. Our findings may help us to refine cognitive theories of depression and be helpful in guiding therapy.

Keywords: interpretation bias, facial emotions, depression, symptom severity

Introduction

Interpretive bias refers to a consistent tendency to interpret emotionally ambiguous stimuli, situations, or events in a negative (or positive) manner (Lawson, MacLeod, & Hammond, 2002). Beck (1979) was the first to note that depressed people are more likely to interpret ambiguous information negatively and consequently one focus of Cognitive Therapy has been to modify such biased interpretations. A number of other experimental studies have established that individuals with depression or dysphoria show negative interpretation biases compared to healthy controls (Mathews & MacLeod, 2005). However none that we know of have investigated the specific pattern of the relationship between negative interpretation bias and depressive symptoms. This is perhaps surprising, following Beck and colleagues' original proposal (Beck, 1967; Clark, Beck & Alford, 1999) that interpretive bias would be a linear function of depressive severity.

As far as we are aware previous studies have only compared depressed (or dysphoric) with non depressed groups. While important, this comparison can only address the presence or absence of a negative bias in the two groups and ignores any variations in the degree of negative interpretation bias within depression. In contrast, the current study set out to investigate whether the magnitude of negative interpretation bias displayed by those with depression is related to the degree of depression they experience. It is by no means inevitable that a higher depression level would be associated with a larger negative interpretation bias, despite Beck and colleagues' predictions. For example, negative interpretation bias may operate in a binary fashion, whereby depressed individuals display a relatively stable, consistent pattern of negative bias, in an 'all or none' manner, irrespective of the degree or severity of their depression. Similarly the pattern of the relationship might follow a number of other functions, such as a quadratic or u-shaped form.

Nevertheless, in line with Beck and colleagues, and the assumptions of many researchers in the field, we hypothesized a positive linear relationship, such that incrementally greater negative interpretation bias would be associated with higher levels of self-reported depressive symptoms.

Understanding the pattern of the relationship between degree of negative interpretative bias and symptom severity is important for several reasons. First, it will help further refine our cognitive theories of depression (Beck, 1967; Clark, Beck, & Alford, 1999; Everaert, Koster, & Derakshan, 2012) by either supporting, or requiring revision of, the current assumption that an incremental linear relationship exists between negative interpretation bias and depressive symptoms. Second, investigating the relationship between the severity of depression and interpretive bias is likely to be helpful in guiding existing and future therapies. For example, Baert, De Raedt, and Koster (2010) found that only those with moderate to severe depressive symptoms showed negative attentional biases. Similar findings for interpretative biases would indicate that therapies developed to combat negative interpretation bias in depression would be best specifically targeted at those displaying corresponding symptom levels. Finally, better understanding of the bias- severity relationship, will help inform the development of new interventions, such as cognitive bias modification (e.g. Micco, Henin, & Hirshfeld-Becker, 2014) by indicating whether these should be designed to achieve a gradual reduction in maladaptive biases and corresponding symptoms, or whether symptomatic improvements should only be expected once a particular bias threshold has been passed. Although there is a wealth of data supporting the dimensional nature of depression, there is virtually no data examining whether cognitive biases operate in a dimensional or all-or-none fashion. Furthermore, cognitive theories of biased processing could accommodate both possibilities. The current study will help address these points.

As mentioned earlier, previous studies have directly compared depressed/dysphoric and non depressed groups (e.g. Wisco & Nolen-Hoeksema, 2010, 2011), rather than examining the pattern of negative interpretation bias *within* depression . Early work employed descriptions of ambiguous events with direct self-reports to index how they were interpreted (Butler & Mathews, 1983; Nunn, Mathews, & Trower, 1997; Voncken, Bogels, & Peeters, 2007). Some studies have assessed judgments or interpretations specific to self-referent descriptions, rather than reactions to ambiguous events commonly experienced in daily life. For example, Mckendree-Smith and Scogin (2000) provided individual personality profiles extracted from MMPI items and asked participants to rate the accuracy and desirability about themselves. With a 2 week presentation-recognition test, Dennard and Hokanson (1986) measured the number of recognitions of positive/nonpathological and negative/pathological adjectives that the participants previously endorsed as descriptive of themselves. Loewenstein and Hokanson (1986) evaluated participants' recall of social information about themselves coming from another person. To avoid possible demand effects, which can contaminate self-report measures, some studies have assessed response latencies to targets following ambiguous words, but failed to find any evidence of interpretative bias in depression (Lawson & MacLeod, 1999; Mogg, Bradbury, & Bradley, 2006). However, latency measures can be problematic with depressed participants due to general psychomotor slowing, and in a follow-up study designed to avoid this problem, Lawson and colleagues (2002) showed that depressive participants exhibited a larger startle response to ambiguous words than did non-depressive controls, thus indirectly revealing their negative interpretative bias. More recently, Sears, Bisson, and Nielsen (2011) used a semantic relatedness judgment task and reported similar conclusions, in that latency measures proved insensitive to depression related differences, whereas error rates revealed a consistent pattern of negative bias

(although see Hindash & Amir, 2012 for a different perspective on latency findings). Again, however, none of these studies investigated possible variations according to severity of depression.

In the present study, we used three complementary methods to assess biases across a range of domains in order to complete a broad and inclusive test of our hypotheses. These were: i) semantic ambiguity represented in text passages ii) nonverbal ambiguity represented in morphing facial expressions and iii) situational ambiguity represented by an imagined speech giving situation. All our measures of negative interpretation bias were indirect. This deliberate choice was designed to minimize the self-presentation and demand effects commonly associated with other measures. The first method, text based semantic ambiguity, used two related techniques to reveal how participants interpret ambiguous passages. In one (the Similarity Rating Test) participants read descriptions of emotionally ambiguous events, and subsequently rated possible positive and negative interpretations for similarity to the original description (Mathews & Mackintosh, 2000; Yiend, Savulich, Coughtrey, & Shafran, 2011). In another, the Scrambled Sentence Task (SST), word strings must be re-ordered so as to make self-relevant sentences, with the words chosen to allow the generation of either a positive or negative meaning. Critically, participants are required to maintain a cognitive load in mind while constructing sentences, thus impeding resource-demanding conscious self-presentation efforts. Students with a history of depression were more likely to construct self-descriptive negative sentences than never-depressed controls, but only under cognitive load (Rude, Covich, Jarrold, Hedlund, & Zentner, 2001; Wenzlaff & Bates, 1998). These results indicate that an automatic interpretive bias in depression may be revealed when more controlled processing is prevented.

The second method employed here assessed responses to nonverbal ambiguity represented by morphing facial expressions. This drew on prior studies suggesting that depressive patients differ from non-depressed controls in their interpretation of emotional facial expressions (Leppänen, Milders, Bell, Terriere, & Hietanen, 2004; Persad & Polivy, 1993; Schaefer, Baumann, Rich, Luckenbaugh, & Zarate, 2010; Surguladze et al., 2004). However, results have varied, perhaps due to the use of stimuli that varied in realism (i.e. schematic versus realistic pictures of faces) and the intensity of the emotion displayed. In real life people perceive a range of facial emotion, including expressions of lower intensity than the standardized pictures used in most previous studies. To address this issue, Joormann and Gotlib (2006) utilized realistic pictures which changed slowly from a neutral to a fully emotional expression, and found that depressed patients required a greater intensity of emotion to correctly recognize happy facial expressions and less intensity to recognize sad facial expressions, compared with either socially phobic patients or healthy controls. We therefore chose the same method for use in the current study.

Finally, our third method used the Anticipated Social Challenge (ASC) task, and was designed to assess the situational and behavioral ambiguity associated with an imagined speech-giving situation. Speaking publically in front of a small group of peers is a commonly encountered situation which carries some degree of stress for most individuals and is open to the alternative prospective interpretations that one may perform fluently, attracting praise, or poorly, attracting criticism. The dependent measures on this task specifically asked about interpretation of the imagined event (anticipated coping and how participants thought they would come across in their performance) as well as subjective anxiety. Moreover research shows that negative interpretations may sometimes only be activated under conditions of stress making the

assessment of interpretation during a stressor a valid and important measurement for the current investigation. In experimental studies, enhancement of emotional response to videos of accidents has been observed following the induction of a negative interpretative bias in normal volunteers (Davis & Clark, 1998; Wilson, MacLeod, Mathews, & Rutherford, 2006). Furthermore, induction of a positive interpretation bias in another study reduced negative affect when anticipating giving a public speech, a potentially stressful social event (Murphy, Hirsch, Mathews, Smith, & Clark, 2007). These findings converge on the conclusion that negative interpretative bias influences the emotional response to events having potentially negative outcomes or meanings. In the current study the ASC task was used an indirect marker of how easily a negative interpretative style can be activated in those varying in depression severity. Overall, there exists supportive evidence that negative interpretive bias, and its affective consequences, are significantly enhanced in depression, but most studies to date have focused on examining the distinction between depressives and healthy controls. Relatively less is known about whether negative interpretations increase progressively as depression becomes more severe. The present study aimed to identify the pattern of the relationship between interpretive bias and depressive symptom severity by using dimensional (regression) analyses within a depressed sample. We hypothesized that the magnitude of interpretive bias (assessed across a range of measures) would vary systematically according to severity of depression. We also sought to establish how much of the variance in severity of depression symptoms was accounted for by negative interpretative bias. Should negative interpretative bias operate in an ‘all or none’ fashion in depression, then the variance explained by the bias should be close to zero. In contrast, if bias changes incrementally with depression severity in a linear fashion, then a significant portion of the variance in depression within our sample should be accounted for by negative

interpretation bias. Healthy participants were not included in our sample because such individuals are thought to possess neither a negative interpretation bias, nor significant depression and would not therefore be an appropriate population within which to test our hypothesis. Categorical (group comparison) analyses were also conducted as a secondary analysis, in order to complement the main findings of the dimensional analysis and for comparability with the depressed groups in previously published group comparison studies. If negative interpretative bias operates in an 'all or none' fashion in depression, then no significant group differences would be expected, since all groups were depressed. In contrast, if the magnitude of bias changes with depression severity, then significant group differences should emerge.

Method

Participants

Participants were recruited using circular emails advertising the study, at the Institute of Psychiatry and more widely across local London universities. Participants were included in the study if they had mild (>= 14) to severe levels of depressive symptoms according to the Beck Depression Inventory II (BDI-II) both at the screening stage and on the day of the experiment that they attended. There were no participants who scored under 14 on the day of the experiment. Participants attended the experiment on average within 1 week since they had completed the BDI-II at the screening stage. Individuals taking psychiatric medication or currently receiving any kind of psychotherapy (n = 3) were excluded prior to testing, as were those screening positive for psychotic disorders, obsessive-compulsive disorder, manic and hypomanic symptoms, alcohol abuse or dependence, according to the Mini-International Neuropsychiatric Interview (MINI) Screen. All participants were English speakers aged 18 to 65 years.

Measures

Mini-international neuropsychiatric interview (MINI) Screen (Sheehan et al., 1998). The screening questionnaire of the MINI asks about a wide range of current psychiatric symptoms relevant to affective and psychotic disorders. The total time for administering the MINI Screen is usually 5-10 minutes.

Beck depression inventory II (BDI-II; Beck, Steer, & Brown, 1996). The BDI II was used to measure severity of depression. This is a 21-question multiple-choice self-report inventory that assesses depressive symptoms in both clinical and nonclinical populations. Results from studies with college students (Beck et al., 1996; Dozois, Ahnberg, & Dobson, 1998; Osman, Kopper, Barrios, Gutierrez, & Bagge, 2004; Steer & Clark, 1997), adult psychiatric outpatients (Steer, Ball, Ranieri, & Beck, 1999) and adolescent psychiatric outpatients (Steer, Kumar, Ranieri, & Beck, 1998), have demonstrated high internal consistency ranging from .92 to .94 (Arnau, Meagher, Norris, & Bramson, 2001; Beck et al., 1996), and moderate to high convergent validity, ranging from .84 to .93 (Beck et al., 1996).

The similarity rating task (SRT; Eysenck, Mogg, May, Richards, & Mathews,1991). The SRT was one measure used to assess participants' interpretive bias in depression. The present study followed the same procedure used in previous studies (Eysenck, Mogg, May, Richards, & Mathews, 1991; Lester, Mathews, Davison, Burgess, & Yiend, 2011; Mathews & Mackintosh, 2000; Yiend et al., 2011). The task comprises two phases: encoding of ambiguous passages, followed by ratings of sentences which disambiguate the passages. In the encoding phase 14 emotionally ambiguous passages were presented in randomized order over three lines of text, followed by a neutral comprehension question (yes or no answer) asking about the

content of each passage. In the subsequent rating phase, participants were presented with two disambiguating target sentences (one a positive interpretation, here called '*target positive*', and the other a negative interpretation, here called '*target negative*') mixed with two foil sentences also having positive or negative meanings but which did not represent legitimate interpretations of the original passage. Participants were instructed to rate each sentence according to how similar it was in meaning to the original passage on a scale from 1 to 4 (1 = very different, 4 = very similar).

The scrambled sentences test (SST; Wenzlaff, 1988; Wenzlaff, 1993). The SST was used as an alternative measure of negative interpretation of ambiguity. Participants unscrambled a total of 20 scrambled sentences (i.e., winner born I am loser a) by placing the numbers 1-5 over the words showing the order in which they appear in a sentence, while under a cognitive load (remembering a 6 digit sequence encoded before starting the task). Each scrambled sentence permits either a positive (" I am a born winner") or negative ("I am a born loser") resolution. At the end of the task participants were instructed to write down the 6 digit number. Participants completed as many sentences as possible within a 4 minute time limit. Based on previous precedent (Rude, Valdez, Odom, & Ebrahimi, 2003; Yiend, Lee, et al., 2014), total negativity scores were calculated as a proportion of the total number of items completed, by dividing the number of valid negative sentences completed by the total number of completed sentences (maximum possible = 20). Errors (e.g., unscrambled with fewer than 5 words) or grammatically incorrect sentences (e.g., a born loser I am) were not counted as valid negative sentences but were included in the denominator (total completed sentences). This yielded a single index score termed '*negativity bias score*' which was used in analyses. Higher values on this score indicated a larger negative interpretation bias.

Facial emotional identification task (FEIT; Joormann & Gotlib, 2006). Following Joormann and Gotlib (2006), photographs of happy, sad, angry, fearful and neutral faces of 13 individuals (Ekman & Friesen, 1976) were continuously morphed from a neutral expression (0% emotion) to the fully emotional expression (100 % intensity of emotion) using the Abrosoft FantaMorph version 3.5.5 software. A total of 52 (13 individuals x happiness, sadness, anger, fear) animated clips were made and used for the current study. Each clip lasted 25 milliseconds and was presented using E-Prime software Version 2.0. The morphs measured 640 x 480 mm and were shown in black-and-white in the middle of the screen on a black background.

Participants were asked to watch each animated clip, press the keyboard SPACE bar as soon as they could identify which emotion was displayed by the face, and finally identify the emotion they had detected by pressing the relevant key (corresponding to Happy, Sad, Anger, and Fear). Main task trials were presented in random order, preceded by 12 practice trials. Mean reaction time (RT) of correct response on each emotion (e.g. RT to identify a sad face correctly) was collected and included in the final analyses, in line with the precedent for analysis of this task set by Joorman and Gotlib (2006).

The anticipated social challenge task (Murphy et al., 2007). This task has been shown to be sensitive to induced interpretation biases. Participants were asked to think about how they would feel if required to give a speech in public and then rate on a 7 point Likert scale, how anxious they felt when anticipating this event ('anticipated anxiety': 1 = extremely relaxed, 7 = extremely anxious), how well they anticipated coping with feelings of anxiety ('anticipated coping': 1 = extremely poorly, 7=extremely well) and how they thought they would come across in their performance ('anticipated performance': 1 = extremely poorly, 7=extremely well).

Procedure.

On arrival participants were given the opportunity to ask questions regarding the study, followed by the completion of a consent form. Along with the BDI-II questionnaire, they had a short interview (10 minutes) concerning their psychiatric histories using the Mini Screen. The participants were then asked to perform the Similarity Rating Task (SRT), the Scrambled Sentence Task (SST) and the Facial Emotional Identification Task (FEIT), followed by the Anticipated Social Challenge Task (ASCT). Order of task presentation was counterbalanced across participants. The total time for the study was 1-1.5 hours.

Results

Participant Characteristics

Participants ranged from 19 to 65 years old (M = 32.96, SD = 11.32); 26.8% (n = 19) were male and 73.2% (n =52) were female. All (n =71) were white. Of the 71 participants, 38 met criteria for a diagnosis of MDD without any significant comorbidity. A further 13 qualified for dysthymic disorder. The remaining 20 had either MDD with comorbid GAD (n=15) or MDD with comorbid Social Anxiety Disorder (n=5) on the MINI Screen. There were no participant exclusions following data collection.

Regression analyses

Prior to conducting regression analyses, zero order correlations were examined (Table 1) Depressive symptom score, as measured by the BDI-II, was significantly associated with the *target negative* score on the SRT, *negativity bias* score on the SST, ratings of anticipated coping and anticipated performance on the ASCT and mean reaction time to correctly identify negative emotions on the FEIT (see Table 1 for the correlations between the aforementioned variables).

Speed of identification of the negative ambiguous emotion on the FEIT revealed very high correlations across the different negative facial emotions (>.9), suggesting that response latencies in sadness, anger and fear trials were essentially the same. For this reason these measures were collapsed into a single measure, 'negative facial emotion', for subsequent regression analyses. As higher depression severity was associated with *faster* reaction times to identify the ambiguous negative emotion of the facial expression, psychomotor slowing could not provide an alternative interpretation of these data.

In a subsequent regression analysis, bias scores (target negative score on the SRT, negativity bias score on the SST, ratings of anticipated coping and anticipated performance on the ASCT and reaction time to correctly identify negative facial emotion on the FEIT) were entered simultaneously as predictors with the depressive symptom score (BDI-II) as the dependent variable, using multiple regression. All bias scores together accounted for 46.1% of the variance in the depressive symptom score, $F = 8.57$, $p < .001$. Target negative score on the SRT ($\beta = 0.45$, $t = 4.28$, $p < .001$) and reaction time to correctly identify negative facial expressions ($\beta = -0.21$, $t = -2.14$, $p < .05$) were significant independent predictors. The remaining variables (negativity bias score on the SST, ratings of anticipated coping and anticipated performance on the ASCT) did not make significant independent contributions to predicting depressive symptom score (all *ts* < 1.16, all *ps* > 0. 21; Table 2).

We then examined how much of the variance in depressive symptoms was accounted for by the significant independent predictors alone (target negative score on the SRT and reaction time to correctly identify negative facial expressions), after controlling for other biases. Results showed that reaction time to correctly identify negative facial expressions accounted for an additional 5.2% of the variance in depressive symptom score, a statistically significant increase

in R^2, $F(1, 62) = 4.50$, $p < .05$. When target negative score on the SRT was added to the model, an additional 16.4% of the variance of depressive symptoms scores was accounted for, with a significant increase in R^2, $F(1, 61) = 18.28$, $p < .001$ (Table 3, Figure 1).

Finally, in a post hoc assessment of the possible role of comorbid anxiety in contributing to the above results we repeated the main analysis using only the subsample without any comorbidity (n=51). Regression analysis revealed the same pattern of significant findings across the predictors, but the total amount of variance explained by the model now increased to 52.7%, with the same or increased beta values across all predictors, with the exception of the SST negativity bias score .

Categorical analyses (Group comparisons)

Group comparisons were conducted as a secondary analysis, in order to complement the main findings of the dimensional analysis and for comparability with previously published group comparison studies. If negative interpretative bias operates in an 'all or none' fashion in depression, then no significant group differences would be expected, since all groups were depressed. In contrast, if the magnitude of bias changes with depression severity, then significant group differences should emerge. Participants were grouped according to mild (score 14-19, n=24); moderate (score 20-28, n=24) or severe (score 29-63, n=23) depression level, in line with standardized cutoffs (Beck et al., 1996; Wang & Gorenstein, 2013). Groups did not differ significantly on age, $F(2,68) = 2.25$, $p = .11$, $\eta 2 = 0.06$ (32.96 ± 11.32; range: 19 -65 years) or gender, $\chi (2,2) = 3.27$, $p = .20$, $V = 0.2$ (male: female = 19:52).

Similarity rating task (SRT). Mean recognition ratings were entered into a 3 x 2 x 2 mixed ANOVA with Group (mild, moderate, severe depression) as the between-subjects factor

and Sentence Type (target, foil) and Valence (positive item/ negative item) as within-subjects factors. Mean recognition rating and standard deviations are presented in Table 4.

There was a significant main effect of Sentence type, F (1, 68) = 56.10, p < .001, ηp2 = 0.45, and of Valence, F (1, 68) = 10.14, p = .002, η_p^2 = 0.13, indicating that target sentences were endorsed more highly than foils, and positive sentences were endorsed more than negative. There was a significant Group x Sentence type x Valence interaction, F (2, 68) = 4.54, p = .014, η_p^2 = .12. Separate analyses for target and foil sentences showed that the Group x Valence interaction remained significant for both targets, F (2, 68) = 10.27, p < .001, η_p^2 = 0.23, and foils, F (2, 68) = 3.82, p = .027, η_p^2 = .10, although the 3-way interaction indicated that this effect was significantly stronger for targets. Separate follow-up one-way ANOVAs, comparing the three groups at each level of valence, revealed significant group differences on negative targets, F (2, 68) = 12.22, p < .001, η^2 = 0.26: both the mildly and moderately depressed group endorsed negative targets less than did the severely depressed group, M = 1.95 vs. 2.62, t (45) = -4.20, p <.001, d = 1.22 and M = 2.09 vs. 2.62, t (45) = -3.70, p < .001, d = 2.02. However, there was no significant difference in negative interpretations between the mildly and moderately depressed groups, M = 1.95 vs. 2.09, t (46) = -1.15, *ns*. There was no significant group difference in positive targets, F (2, 67) = 1.38, *ns.*

Scrambled sentence task (SST). To examine whether there would be a group difference on *negativity bias score* (i.e. mean proportion of negative sentences constructed), a one way ANOVA was carried out, along with follow-up independent sample t tests. Table 4 presents means and standard deviations of negative sentences by group.

There was a significant group difference in the proportion of negative sentences, F (2, 68) = 4.41, p = .016, η^2 = .13, with the severely depressed group producing more negative sentences

than either the mildly depressed, M = 50.53 vs. 36.96, $t(45) = -2.28$, $p = .027$, $d = .66$ or the moderately depressed group, M = 50.53 vs. 36.46, $t(45) = -2.38$, $p = .022$, $d = .70$. There was no significant difference in negative sentences between the mildly and moderately depressed groups, $M = 36.96$ vs. 36.46, $t\ (46) = .127$, *ns*.

Facial emotion identification task (FEIT). Table 4 presents means and standard deviations (in parentheses) of reaction time in milliseconds to identify the correct emotion for each expression by group. Mean reaction times were entered into a 3 (Group: mildly depressed, moderately depressed, severely depressed) x 4 (Facial emotion: happy, sad, angry, fearful) mixed ANOVA. There was a significant main effect of facial emotion, $F\ (2, 64) = 64.57$, $p < .001$, $\eta_p^2 = .50$, and of group, $F\ (2, 64) = 3.63$, $p = .032$, $\eta_p^2 = .10$, which was qualified by a significant interaction of facial emotion by group, $F(6, 64) = 3.29$, $p = .004$, $\eta_p^2 = .09$. This reflected significant group differences for sad, $F\ (2, 64) = 3.45$, $p = .038$, $\eta^2 = .10$ angry, $F\ (2, 64) = 4.71$, $p = .01$, $\eta^2 = .13$ and fearful, $F\ (2, 64) = 4.06$, $p = .02$, $\eta^2 = .11$ but not for happy facial expressions, $F(2, 64) = 1.47$, $p = .24$. Further contrasts revealed that the severely depressed group were faster than the mildly depressed group in recognising sad, M = 10042ms vs. 13320ms, $t(64) = 2.51$, $p = .015$, $d = .70$ and fearful facial emotions, M = 8886ms vs. 12236ms, $t(64) = 2.84$, $p = .006$, $d = .77$. The severely depressed group also recognized anger facial emotion earlier than mildly, 9851ms vs.12982ms, $t(64) = 2.89$, $p = .005$, $d = .81$ and moderately depressed groups, M = 9851ms vs. $M = 13629$ms, $t(64) = 2.42$, $p = .018$. $d = .64$.

Anticipated social challenge task (ASCT). To examine whether there would be a group difference on mean scores of anticipated coping and anticipated performance, a one-way ANOVA was carried out, followed by an independent sample t tests when necessary. As this task required multiple ANOVA tests, Bonferroni correction was used to protect against an inflated

Type I error rates from current analyses. As such, only those for which $p < .05/3 = .0166$ were considered significant.

The results revealed that there was a significant effect of group on anticipated coping, $F(2, 70) = 5.83$, $p = .005$, $\eta^2 = .15$. Anticipated coping was significantly higher in the mildly depressed than the severely depressed group, M = 4.29 vs. 3.04, $t(68) = 3.41$, $p = .001$, $d = .98$. There was also a significant effect of group on anticipated performance, $F(2, 70) = 8.10$, $p = .015$, $\eta^2 = .12$, with significantly higher ratings in the mildly depressed than the severely depressed group, M = 4.00 vs. 2.83, $t(68) = 2.99$, $p = .004$, $d = .89$. Groups did not differ on ratings of anticipated anxiety, $F < 1$. Means and standard deviations of each rating in the ASCT by each group are presented in Table 4.

Discussion

In the present study, we sought to test the hypothesis that the magnitude of interpretive bias, assessed across a range of domains, would vary systematically according to severity of depression and, were that so, to establish how much of the variance in depression symptoms could be accounted for. We were also testing the alternative possibility that negative interpretative bias might operate in an 'all or none' fashion in depression, in which case the portion of symptom variance explained by the bias should be close to zero. Results overall revealed support for the hypothesis, in that a significant portion of the variance in depression within our sample was accounted for by negative interpretation bias suggesting that bias changes incrementally with depression severity in a linear fashion. In regression analyses, just under half of the variance (46.1%) in depressive symptoms was accounted for by the combination of negative interpretation biases, measured across domains of semantic, nonverbal and situational

information processing. Negative interpretation scores on the similarity rating task and reaction time to recognize non-verbal negative facial expression on the facial emotional identification task made significant independent contributions. Secondary group comparison analyses were consistent with these conclusions.

Individually, in zero order correlations, depressive symptoms were significantly associated with each of the bias scores, whether measured by semantic ambiguity represented in text passages (scrambled sentences, SST, and similarity ratings, SRT, tasks), nonverbal ambiguity represented in morphing facial expressions (facial emotional identification task, FEIT) or situational ambiguity represented by an imagined speech giving situation (anticipated social challenge task, ASCT). While our primary purpose was to estimate the overall importance of negative interpretation bias in accounting for depressive symptoms, it is nevertheless instructive to consider the differential contributions of our different measures of bias. It was clear from the regression results that the single most powerfully predictive bias was that captured by the SRT measure of semantic ambiguity depicted in passages of text. This measure is arguably one of the purest tests of biased interpretation of ambiguity, as it minimizes likely attentional effects and controls for response bias. Variants of this measure are widely used, both to manipulate biased interpretations using cognitive bias modification, and to measure the success of doing so (e.g. Yiend, Lee, et al, 2014; Yiend, Parnes et al., 2014). Nonverbal interpretation of ambiguity, measured using identification of the emotion present during clips of morphing facial expressions, made a small additional independent contribution to explaining symptoms. As noted earlier, the size of this speeding effect may have been reduced artificially by the psychomotor slowing associated with increasing depression level.

In contrast, neither imagined speech-giving, nor scrambled sentences negativity bias, made any independently significant contribution. Given that these tasks did contribute to the overall model, this may simply reflect their smaller independent effect sizes, which would require a greater sample size to achieve independent significance or, these results might also be due to overlapping constructs between measures (e.g., the SRT and SST). Another possibility is that, despite being established as measures of interpretation bias associated with depression, these tasks provide a less sensitive measure of interpretive differences across different levels of current depression than the other measures. In summary, our results suggested that the individual domains of semantic ambiguity captured in text passages and non-verbal ambiguity captured in facial expressions were the most influential forms of negative interpretation bias in accounting for depressive symptoms.

Our group analyses confirmed the results of the regression analyses. On measures of semantic ambiguity, the SRT and the SST, we found that negatively biased interpretation was more salient in the severely depressed individuals than the mild and moderate depressives, and follow up tests revealed that mild and moderate depressives did not differ significantly. These results are consistent with those obtained by Dennard and Hokanson (1986) and Loewenstein and Hokanson (1986), in that mild and moderate depressives did not differ in their degree of interpretation bias. However, these two studies did not include severe depressives, which precluded the identification of a differing effect on interpretation bias between such mild-moderate depressives and severe depressives. Our data extend these conclusions by demonstrating that severe depressives differ from those with mild and moderate depression in their degree of negative interpretation bias for ambiguous events.

Similar results were obtained for nonverbal ambiguity, using a test involving the interpretation of neutral to negative morphed facial expressions of emotion. Severely depressed people recognized sad and fearful faces earlier than those with only mild symptoms, and angry faces earlier than both the mild and moderate depressives. This suggests that severe depressives are more likely than mild or moderately depressed individuals to detect subtle negative facial expressions at an early point. However, no group difference was detected for speed of correctly identifying morphing happy facial expressions. There have been inconsistent findings in this regard. For example, two previous studies (Joormann & Gotlib, 2006; Surguladze et al., 2004) found that MDD participants needed greater emotional intensity, compared with healthy participants, to recognize happy facial expressions correctly when slowly morphing from neutral to happy. However, Schaefer et al. (2010) reported no difference between MDD patients and controls under similar conditions. Furthermore, these studies examined group differences between MDD patients and healthy controls, rather than investigating the effect of symptom severity within a depressed sample, as reported here. Thus, although we used the same task as the above studies, the contrast of interest was conceptually different. While we might expect depressed participants to differ from healthy controls in their interpretation of happy facial expressions based on previous literature, we are not aware of any studies that have directly addressed this question in the case of severe versus mild depression. As we argued at the outset, it is entirely possible that any pattern of biased processing may be initiated with the onset of depression but, thereafter, remain relatively stable with further incremental changes in depression severity.

Finally, on the measure of situational and behavioral ambiguity, the response to anticipating giving a public speech, the severely depressed group reported lower ratings for

coping with the situation, compared with mild depressives. Interestingly, the level of anticipated anxiety in such a situation did not differ between the groups. This finding suggests that depression severity is not associated with subjective anxious response *per se*, but with ability to cope with such situations, consistent with the results reported by Lester et al (2011).

Considered collectively, the present study provides experimental evidence that negatively biased interpretations of information similar to that encountered in everyday life, are associated with elevated depressive symptoms. Our hypothesis that the magnitude of negative interpretive bias (assessed across a range of measures) would vary systematically according to severity of depression was well supported in the present data across both types of analyses. The finding that almost half the variance in depressive symptom severity is related to the degree of bias in the interpretation of ambiguity suggests important refinements are needed to both theoretical models and treatments targeting negative interpretation bias. In addition the grouped data analyses suggest a discontinuity in which interpretation bias becomes markedly more pronounced only in severe depression.

It is important to note, however, that we do not intend to imply any causal association between bias and symptoms from the present data, which were purely correlational in design. Nevertheless, the significant body of work around the modification of interpretative biases has already established interpretive bias mechanisms as key causal factors in a variety of psychopathology, including depression (e.g. Hoppitt, Mathews, Yiend, & Mackintosh, 2010a, 2010b; Yiend, Lee, et al., 2014; Yiend, Parnes, Shepherd, Roche, & Cooper, 2014; Yiend et al., 2011) and the present findings should therefore be interpreted within this wider context. Depression continues to present a significant mental healthcare challenge, with long term outcomes in the UK worse than previously thought (Yiend et al., 2009), serving to underline the

increasing need to better understand the cognitive mechanisms driving maintenance and relapse. These data make a small contribution to this mission.

It is important to note several further limitations to this investigation. Lack of a non-depressed control group prevented us from identifying interpretation biases which best distinguish depression from healthy functioning. This may account for the relative lack of differences on positively valenced material, since healthy functioning is typically characterised by positive or protective biases. Another limitation was that our only measure of depressive symptoms was the BDI-II. While this measure is ideal for capturing symptom severity, it is not a clinician-administered tool and suffers the limitations associated with any self-report measure. Future work might seek to measure symptom severity using clinician administered assessment, which would permit stronger conclusions about the relationship between clinical symptoms and strength of interpretative bias. In particular it would be informative to examine whether or not the diagnostic threshold corresponds to a discrete change in interpretative bias function. Another limitation is that our findings concerning the relationship between interpretation of situational ambiguity using the anticipated social challenge task and depression severity should be taken with caution. Although the test used has previously been found to be sensitive to differences in social anxiety (Murphy et al., 2007), it may not have been the best measure of depression-related concerns on all dimensions. Arguably the 'inability to cope' dimension provided the best fit to the specific concerns of depressed individuals, and as we have argued elsewhere (Yiend, Mathews, et al., 2014) closely matching stimuli to the primary concerns of the target patient group may be critical to observing cognitive bias phenomena. A further limitation is that we cannot exclude the possibility that anxious mood might have contributed to our results, especially those on the anticipated social challenge task, given the high comorbidity between

depression and anxiety. As we did not design our study to compare anxiety and depression, nor include a measure of comorbid anxiety, this could not be easily addressed in the present study, but could be investigated in future work. However, tentative post hoc analyses conducted on the subsample of our patients without anxiety comorbidity revealed the same pattern of results but with an even stronger relationship between predictors and depressive symptoms, in which over half the variance was now accounted for. Finally, the current findings are limited in terms of their generalizability due to our sample being entirely Caucasian and predominantly female. Further work in a sample with greater ethnic diversity and a more balanced gender ratio is warranted.

Overall these findings have important implications for psychological treatment research and particularly for the selection of treatment targets in newer methods such as cognitive bias modification or existing cognitive therapy. In demonstrating a linear relationship between depression and negative interpretation bias our data suggest that gradual reduction in negative bias should correspond to a similar incremental reduction in symptom severity. Furthermore, if negative interpretation biases are present at greater intensity in more severe, as compared to milder depression levels, then the extent to which they are the focus of treatment can be correspondingly intensified. This might, for example, take the form of initially encouraging non-negative interpretations, before progressing towards overtly positive interpretations (see Mathews et al., 2007 for discussion of this concept of 'graded' interpretations). Indeed this has been the approach already used in some variants of interpretation bias modification (Mathews et al., 2007; Lester et al., 2011). Likewise increasing the 'dose' of therapy time devoted to identifying and addressing negative interpretations of everyday emotional ambiguity, or increasing the number and duration of interpretation bias modification sessions could be

appropriate for more severe depression. Finally our data also indicate the range of negative interpretative bias manifestations that could usefully be targeted include semantic, nonverbal and situational contexts.

Conflicts of interest statement

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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Ethical issue

The authors confirm that the study was conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All participants in the present study signed a consent at the outset of the experiment. The work was approved by King's College London Ethical Review Board (PNM/09/10-59). No animals have been used in this study.

Originality of the manuscript

The manuscript represents original research and is not under consideration for publication in any other outlet.

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Table 1.

Correlations between depressive symptom severity as measured by the BDI-II and other variables (N = 71)

	1	2	3	4	5	6	7	8	9
1. Depressive symptoms score (BDI-II)	-								
2. SRT-*target negative* score	.52***	-							
3. SST- *negativity bias* score	.33**	.40**	-						
4. FEIT-sad	-.28*	-.15	-.14	-					
5. FEIT-anger	-.31*	-.10	-.10	.93***	-				
6. FEIT-fear	-.30*	-.09	-.19	.93***	.93***	-			
7. FEIT-happy	-.26*	-.17	-.28*	.88**	.87**	.89**			
8. ASCT-anticipated coping	-.38**	-.23	-.21	.11	.14	.17	.07		
9. ASCT-anticipated performance	-.33**	-.21	-.15	.07	.09	.06	.09	.56***	
10. ASCT-anticipated anxiety	.05	-.04	-.04	-.18	-.18	-.13	-.14	-.30*	-.37**

Note. Values are Pearson's *r*. * Indicates significant difference between variables at $p < .05$; ** indicates significant difference between variables at $p < .01$; ***indicates significant difference between variables at $p < .001$. BDI-II = Beck Depression Inventory II; SRT = Similarity Rating Task; SST = Scrambled Sentence Task; FEIT = Facial Emotional Identification Task; ASCT = Anticipated Social Challenge Task.

Table 2.

Multiple regression of semantic ambiguity, non-verbal ambiguity and situational ambiguity predicting depressive symptom score (N = 71)

Predictor	β	*t*	*p*	R^2	*95% Confidence Interval*	*Partial correlations*
SRT-target negative score	**.45**	**4.28**	**<.001**		3.856-10.636	.48
FEIT- reaction time to correctly identify negative facial expressions	**-.21**	**-2.14**	**<.05**		-.001-.000	-.27
SST- negativity bias score	.11	1.04	ns	.461	-.05-.16	.12
ASCT-anticipated coping	-.15	-1.32	ns		-2.54-.52	-.17
ASCT-anticipated performance	-.13	-1.10	ns		-2.30-.67	-.09
ASCT-anticipated anxiety	-.05	-.48	ns		-1.46-.89	-.06

Note. Values are β, t, and p for the contribution of independent variables predicting depressive symptom score measured by the BDI-II. Variables in bold made significant independent predictions to the overall model shown.

Table 3.

Hierarchical multiple regressions (N = 71)

	Predictor	*β*	*t*	ΔR^2	ΔF	*95% Confidence Interval*	*Partial correlations*
1	SST- negativity bias score	.321	2.69**			.039-.263	.32
	ASCT-anticipated coping	-.22	-1.63	.245	5.04***	-3.212-.328	-.18
	ASCT-anticipated performance	-.16	-1.18			-2.727-.700	-.12
	ASCT-anticipated anxiety	-.05	-0.44			-1.63-1.048	-.06
2	FEIT- reaction time to correctly identify negative facial expressions	.24	-2.12*	.052	4.50*	-.001-.000	-.26
3	SRT- score	.45	4.28***	.164	18.28***	3.86-10.64	.48

Table 4.
Means and standard deviations of each measure of semantic ambiguity, non-verbal ambiguity and situational ambiguity tasks by group

	a. Mild depression (N=24)	b. Moderate Depression (N=24)	c. Severe depression (N=23)	*p*	Contrast
Similarity Rating Task (SRT)					
Target positive	2.61(.48)	2.43(.52)	2.40(.51)		*ns*
Target negative	1.95(.48)	2.09(.35)	2.62(.60)	.001[p]	c >a,b
Foil positive	1.93(.56)	1.97(.57)	1.92(.51)		*ns*
Foil negative	1.64(.41)	1.67(.67)	2.03(.53)		c > a,b
Scrambled Sentence Task (SST)					
Negativity Bias	36.96(13.83)	36.46(13.47)	50.53(25.55)	<.001	c > a, b
Mean reaction time to recognize correct facial emotion with standard deviations in parentheses					
Happy	9678.76(2260.69)	8961.23(2114.30)	7919.07(5188.08)	*ns*	
Sad	13320.55(2869.33)	12630.23(3653.90)	10042.83(5977.76)	.038	c > a
Anger	13629.23(2931.94)	12982.70(3727.28)	9851.99(5882.83)	.012	c > a, b
Fear	12236.50(2760.86)	10974.95(3023.73)	8886.33(5517.32)	.022	c > a
Anticipated Social Challenge Task (ASCT)					
Anticipated coping	4.29(1.46)	3.71(1.20)	3.04(1.07)	.005	a > c
Anticipated performance	4.00(1.50)	3.42(1.38)	2.83(1.11)	.015	a > c
Anticipated anxiety	4.50(1.50)	4.83(1.74)	4.91(1.62)	*ns*	

Note. [p]: 3 way interaction; Data of 4 participants (1 from the mildly depressed group and 3 from the severely depressed group) from facial emotion identification task was missing due to a technical problem: number of mildly depressed group = 23, number of moderately depressed group = 24, number of severely depressed group = 20.

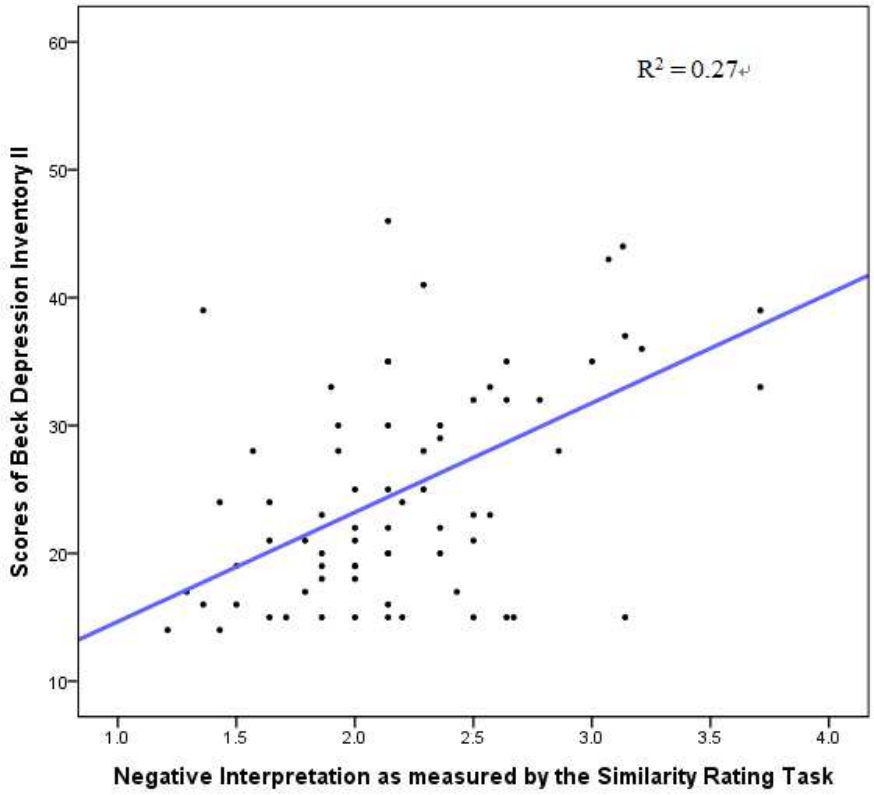

Figure Captions

Figure 1
Linear relationship between depressive symptoms and negative interpretation bias

Highlight

- Variation of negative interpretive bias is associated with depressive symptoms severity
- Under half of the variance in depressive symptom severity is accounted for by negative bias
- Negative bias manifests especially strongly at the most severe levels of depression
- A focus on reducing negative interpretive bias in severe depression may indeed be helpful
- An incremental reduction of negative interpretive biases may correspond to a similar reductions in symptoms